Claims

We claim:

1. An internal combustion engine, comprising:

a choke valve;

a choke operating device that operates the choke valve;

a thermally conductive assembly in direct contact with exhaust gases produced by the engine;

a thermally responsive member in thermal communication with the thermally conductive assembly such that the thermally conductive assembly transfers heat from the exhaust gases to the thermally responsive member; and

a mechanism that moves in response to the thermally responsive member to cause the choke valve to remain in at least a partially open position during engine starting when the thermally responsive member senses a temperature above a predetermined temperature.

2. The engine of claim 1, wherein the choke operating device includes an air vane that moves as a function of engine speed.

3. The engine of claim 2, wherein the engine includes a fan, and wherein the air vane moves in response to air flow produced by the fan.

4. The engine of claim 1, wherein the choke valve is interconnected to the choke operating device via a choke linkage, the choke linkage including a choke lever.

5. The engine of claim 4, wherein the choke linkage includes a biasing member, and wherein the choke valve is biased closed by the biasing member.

6. The engine of claim 4, wherein the choke linkage includes a first choke arm and a second choke arm, and wherein the choke operating device, the first choke arm, and the second choke arm are an integrally-formed unitary body that directly acts on the choke valve.

7. The engine of claim 6, wherein the choke valve is biased closed by a biasing member, and wherein the second choke arm includes a protrusion, such that the biasing member is coupled to the protrusion.

8. The engine of claim 1, wherein the thermally conductive assembly further comprises a thermally conductive element.

9. The engine of claim 8, wherein the thermally conductive element includes a chamber, and wherein the thermally responsive member is disposed in the chamber.

10. The engine of claim 8, wherein the thermally conductive element includes a first portion, a second portion, and a bridge.

11. The engine of claim 10, wherein each of the first portion, second portion, and bridge has a width, and wherein the width of the bridge is more narrow than the width of either the first or second portions.

12. The engine of claim 10, wherein the thermally responsive member is coupled to the first portion of the thermally conductive member.

13. The engine of claim 1, wherein the thermally conductive assembly includes a cover.

14. The engine of claim 13, wherein the cover is coupled in mechanical contact with the thermally responsive member.

15. The engine of claim 1, wherein the thermally responsive member has at least one of a high coefficient of thermal expansion and of thermal contraction such that the thermally responsive member either expands or contracts in response to temperature changes.

16. The engine of claim 15, wherein the thermally responsive member includes a bimetallic coil.

17. The engine of claim 16, wherein the bimetallic coil has a radial configuration.

18. The engine of claim 1, wherein the thermally conductive assembly is disposed adjacent to an engine exhaust system.

19. The engine of claim 18, wherein the thermally conductive assembly is disposed adjacent to an engine muffler.

20. The engine of claim 1, wherein the thermally conductive assembly at least partially surrounds the path of the exhaust gases.

21. The engine of claim 1, wherein the specific geometry of the thermally conductive assembly is chosen to control the heat transfer to the thermally responsive member.

22. The engine of claim 1, wherein the mechanism includes a stop lever coupled to the thermally responsive member such that when the thermally responsive member senses a temperature above the predetermined temperature, the stop lever interacts with the choke operating device, and the choke operating device interacts with a choke lever to hold the choke valve at least partially open during starting of the engine.

23. The engine of claim 1, wherein the mechanism includes a linkage, and wherein the linkage includes a stop lever, a tab coupled to the choke operating device that interacts with the stop lever, a choke linkage coupled to the choke operating device including a choke lever, the choke lever adapted to operate the choke valve.

24. The engine of claim 1, further comprising a lever linkage coupled to the thermally conductive assembly, and wherein the lever linkage includes a link arm, a first lever link, and a second lever link.

25. An automatic choke apparatus coupled to an internal combustion engine, the automatic choke apparatus comprising:

a choke valve;

a thermally conductive assembly in direct contact with exhaust gases produced by the engine;

a thermally responsive member in thermal communication with the thermally conductive assembly such that the thermally conductive assembly transfers heat from the exhaust gases to the thermally responsive member; and

a mechanism that moves in response to the thermally responsive member to cause the choke valve to remain in at least a partially open position during engine starting when the thermally responsive member senses a temperature above a predetermined temperature.

26. The automatic choke apparatus of claim 25, wherein the choke valve is operated by a choke operating device via a choke linkage, the choke linkage including a choke lever.

27. The automatic choke apparatus of claim 26, wherein the choke linkage includes a first choke arm and a second choke arm.

28. The automatic choke apparatus of claim 26, wherein the choke operating device includes an air vane.

29. The automatic choke apparatus of claim 28, wherein the choke operating device, the first choke arm, and the second choke arm are integrally-formed as a unitary body.

30. The automatic choke apparatus of claim 25, wherein the mechanism includes a stop lever coupled to the thermally responsive member such that when the thermally responsive member senses a temperature above the predetermined temperature, the stop lever interacts with the choke operating device to hold the choke valve at least partially open during starting of the engine.

31. The automatic choke apparatus of claim 25, wherein the thermally conductive assembly further comprises a thermally conductive element.

32. The automatic choke apparatus of claim 31, wherein the thermally conductive element includes a chamber and wherein the thermally responsive member is disposed in the chamber.

33. The automatic choke apparatus of claim 31, wherein the thermally conductive element includes a first portion, a second portion, and a bridge.

34. The automatic choke apparatus of claim 33, wherein the second portion includes a flange, and wherein the flange adapted to cooperate with at least a portion of the engine.

35. The automatic choke apparatus of claim 31, wherein the thermally conductive assembly includes a cover.

36. The automatic choke apparatus of claim 35, wherein the cover is coupled to the thermally conductive element in mechanical contact with the thermally responsive member.

37. The automatic choke apparatus of claim 25, wherein the thermally responsive member has at least one of a high coefficient of thermal expansion and of thermal contraction such that the thermally responsive member either expands or contracts in response to temperature changes.

38. The automatic choke apparatus of claim 37, wherein the thermally responsive member includes a bimetallic coil.

39. The automatic choke apparatus of claim 25, wherein the thermally conductive assembly is disposed adjacent to an engine exhaust system.

40. The automatic choke apparatus of claim 39, wherein the thermally conductive assembly is disposed adjacent to an engine muffler.

41. The automatic choke apparatus of claim 25, wherein the thermally conductive assembly at least partially surrounds the path of the exhaust gases.

42. The automatic choke apparatus of claim 25, wherein the mechanism includes a linkage, and wherein the linkage includes a stop lever, a choke operating device that engages the stop lever, a choke linkage coupled to the choke operating device, and a choke lever coupled to the choke linkage, the choke lever adapted to operate the choke valve.

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43. The automatic choke apparatus of claim 25, further comprising a lever linkage coupled to the thermally conductive assembly, and wherein the lever linkage includes a link arm, a first lever link, and a second lever link.

44. A method of operating a choke in an internal combustion engine using exhaust heat, the internal combustion engine having a choke valve operable by a choke operating device in response to the speed of the engine, the method comprising:

placing a thermally conductive assembly in direct contact with exhaust gases produced by the engine;

transmitting heat from the exhaust gases to the thermally conductive assembly through a solid material;

transmitting heat from the thermally conductive assembly to a thermally responsive member in thermal contact with the thermally conductive assembly;

providing a linkage between the thermally responsive member and the choke operating device; and

preventing the choke valve from closing completely during restarts of the engine when the thermally responsive member senses that the temperature of the engine has reached a predetermined temperature.

45. The method of claim 44, further comprising placing the thermally conductive assembly adjacent to an engine exhaust system.

46. The method of claim 45, wherein placing the thermally conductive assembly adjacent to an engine exhaust system includes placing the thermally conductive assembly adjacent to an engine muffler.

47. The method of claim 44, further comprising placing the thermally conductive assembly at least partially surrounding the path of the exhaust gases.

48. The method of claim 44, wherein the preventing step includes providing a mechanism that restricts movement of the choke operating device.

49. The method of claim 44, wherein transmitting the heat to the thermally responsive member causes expansion or contraction of the thermally responsive member, and wherein the expansion or contraction of the thermally responsive member retains the choke valve in an at least partially open position once the engine reaches the predetermined temperature.

50. A choke operating assembly for operating a choke valve in an internal combustion engine, the choke operating assembly comprising:

an air vane, the air vane including a tab; and

a choke linkage, the choke linkage including

a first choke arm,

a second choke arm, the second choke arm including a protrusion;

wherein the air vane, first choke arm, and second choke arm are integrally formed as a unitary body.

51. The choke operating assembly of claim 50, wherein the choke valve is biased closed by a biasing member, and wherein the protrusion on the second choke arm is coupled to the biasing member.

52. The choke operating assembly of claim 50, wherein the tab of the air vane is configured to interact with a stop lever that is movable due to temperatures within the engine to cause the choke valve to remain in at least a partially open position during engine starting when the engine temperature is above a predetermined temperature.

53. The choke operating assembly of claim 50, wherein the choke operating device is injection molded.

54. The choke operating assembly of claim 50, wherein the choke operating device is made from a material including nylon.

55. The choke operating assembly of claim 50, further comprising a choke lever coupled to the choke linkage.